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(56) Documents Cited
**EP 1152628 A1**
**EP 1026911 A2**
**WO 1999/060809 A1**
**EP 1035677 A1**
**WO 2000/049816 A2**

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INT CL⁷ **H04B** 1/69 7/06 7/10 7/216, **H04Q** 7/36 7/38
Other:

(54) Abstract Title
# Code assignment in cellular communications systems

(57) A code assignment technique for a cellular communications system combines the use of multiple channelisation code trees with space division multiple access thereby enhancing spectral efficiency and user capacity. A base station (1) monitors the angular separation of two mobile stations (3, 4) in a cell (2) and initially assigned the same code. When the angular separation reaches a minimum threshold value, a code re-assignment is effected in a manner dependant upon the relative number of high data rate and low data rate users already active in the cell (2).

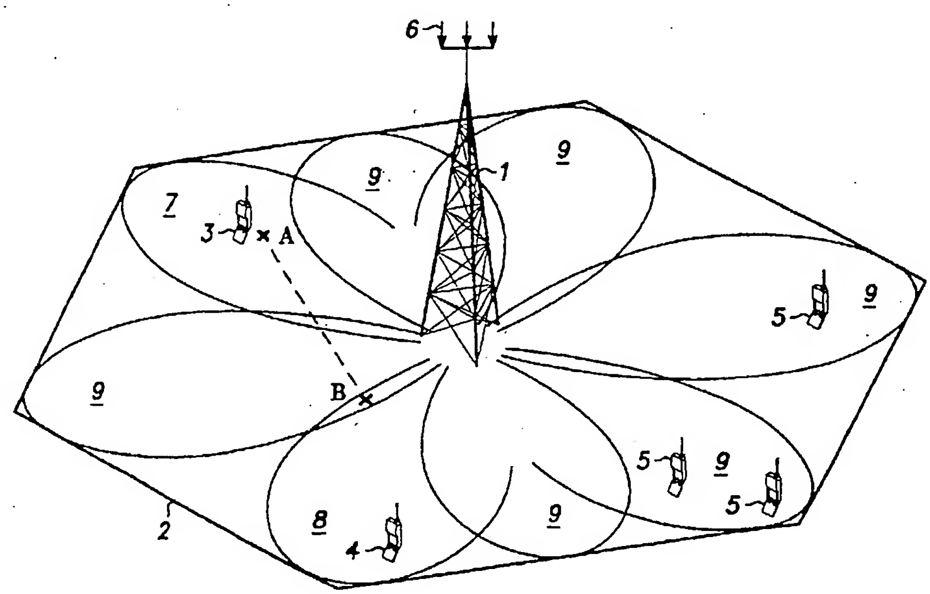


*FIG. 1*

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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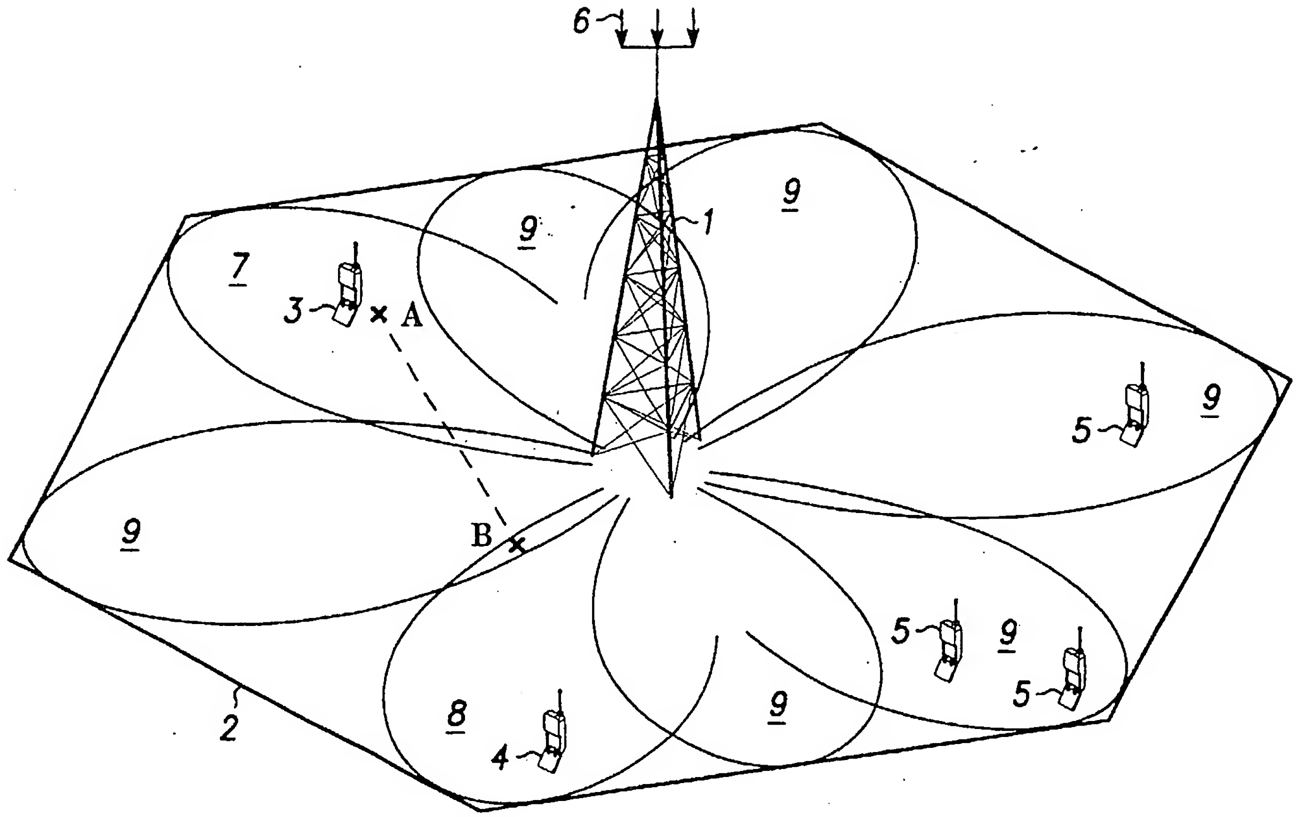
6
1
9
9
7
3
A
9
5
9
B
2
5
9
5
8
4
9

FIG. 1

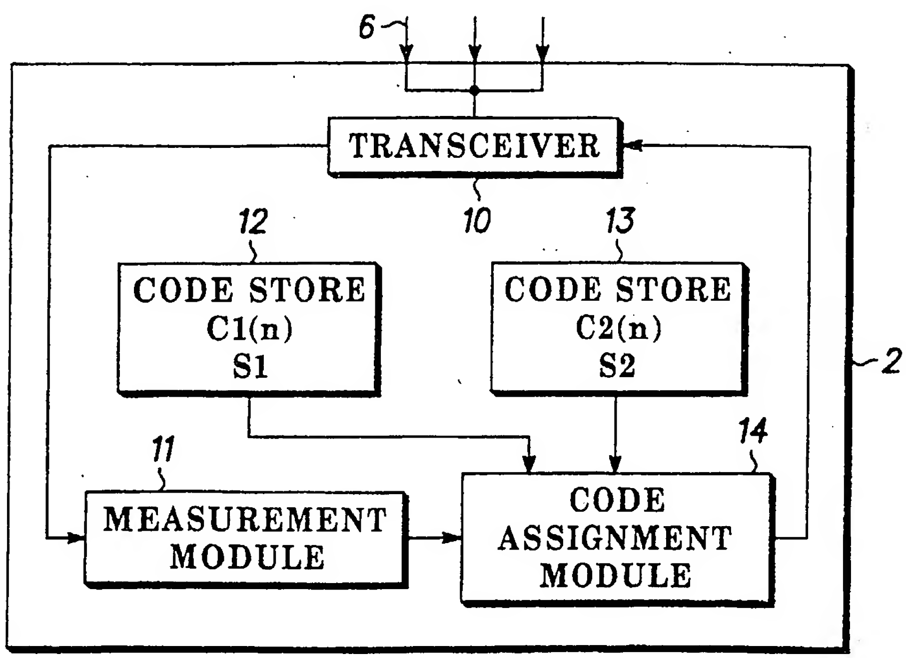
6
TRANSCEIVER
10
12
13
CODE STORE
C1(n)
S1
CODE STORE
C2(n)
S2
2
11
14
MEASUREMENT
MODULE
CODE
ASSIGNMENT
MODULE

FIG. 2

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# CODE ASSIGNMENT IN CELLULAR COMMUNICATIONS SYSTEMS

This invention relates to code assignment in cellular communication systems and particularly to code division multiple access systems.

In a cellular communication system, a plurality of base stations provides a radio telecommunications service to a plurality of remote subscriber units often termed "mobile stations". Each base station defines a particular geographical area or cell proximate to the base station to produce coverage areas. The communications link from the base station to a mobile station is referred to as the downlink. Conversely, the communications link from a mobile station to the base station is referred to as the uplink. As the mobile station moves from one cell to the next, the communications link is transferred from its current serving base station to a neighbouring base station using a procedure known as handover. Typically, each mobile station performs real-time measurements and reports them back to its serving base station. Such measurements may relate to quality and strength of signals received from the base station (i.e. on the downlink).

Multiple access techniques permit the simultaneous transmissions from several mobile stations to and from a single base station. One type of multiple access technique is known as code division multiple access (CDMA) which employs spread-spectrum signalling. Individual users in the CDMA communications system use the same carrier frequency but are separated by the use of individual spreading codes. Hence, multiple communications channels are assigned using a plurality of spreading codes within the portion of radio spectrum, each code being uniquely assigned to a mobile station. In a direct sequence CDMA communication system, the signals are, prior to being transmitted, multiplied by a high rate code whereby the signal is spread over a larger frequency spectrum. A narrow-band signal is thus spread and transmitted as a wide-band signal. At the receiver the original narrow-band signal is re-generated by multiplication of the received signal with the same code. A signal spread by use of a different code will, at the receiver, not be de-spread but will remain a wide-band signal. In the receiver, the majority of interference caused by interfering signals received in the same frequency spectrum as the wanted signal can thus be removed by filtering. Consequently, a plurality of mobile stations can be accommodated in the same wide-band spectrum by allocating different codes for different mobile stations. Codes are chosen to minimise the interference caused between mobile stations typically by choosing orthogonal codes when possible. In the frequency division duplex (FDD)

arrangement, sometimes termed wide-band CDMA (WCDMA), one carrier frequency is allocated for communications on the downlink and another carrier frequency is allocated for communications on the uplink. In a time division duplex (TDD) arrangement, the same carrier frequency is used for both uplink and downlink. A repeating time frame is divided into an interval with time slots used in the uplink direction and another interval with time slots used in the downlink direction. The allocation of time slots to either uplink and downlink transmission is controlled by the base station, taking into account the number of mobile stations it is required to support at any given time and this time frame structure is broadcast to each mobile station requiring communications services.

This invention can be applied to either an FDD or TDD arrangement.

In a WCDMA cellular network, isolation between users on the downlink is accomplished through a combination of user-specific channelisation codes, and a cell-specific scrambling code. In addition, user transmissions are synchronised and, as a result, the chosen class of user-specific channelisation codes are orthogonal variable spreading factor (OVSF) codes.

On the downlink in a WCDMA cellular network, factors that limit user capacity include multiple access interference and OVSF code limitation. OVSF codes are generated recursively to form a binary tree-structure. A tree can be grown or pruned in any desired fashion, and the collection of codes at the "leaves" of a given tree-structure collectively form an orthogonal set having different spreading factors. Any given OVSF code can be assigned to a particular mobile station only if no other code on the path from the given code to the root of the tree, or in the subtree that stems from it has already been assigned, otherwise interference levels become unacceptable. Those codes which are close to the root of the tree have low spreading factors. Codes more distant from the root have higher spreading factors. Users of low data rate communications services (eg. voice) can operate with comparatively high spreading factors and still enjoy an acceptable quality of service. High data rate users, on the other hand, require low spreading factor codes for acceptable quality of service.

Due to the nature in which OVSF codes are constructed, the assignment of a low spreading factor code to a high data rate user blocks a large part of the code resource. In addition, mobile users who are served by multiple cells simultaneously

(eg. whilst in "soft" handover) require the assignment of additional code resource. Therefore, when there are large numbers of connections in soft handover, the problem of code limitation becomes more severe.

One known method of mitigating the problem of code limitation employs a secondary code tree within a given cell. Here, isolation between the primary and secondary code trees is achieved through the use of a primary and secondary scrambling code in the cell. In situations where a second OVSF (channelisation) code tree is required on the downlink, it is not unreasonable to expect that a number of OVSF (channelisation) codes allocated in the primary tree may also be allocated in the secondary tree. Under these circumstances, there will be an increase in intra-cell interference, the level of which is dependent on the partial cross-correlations exhibited between the primary and secondary scrambling codes.

It is known that adaptive antennas can be used in situations where two users (say) have the same channel resource requirements but are spatially separable. Consider the case where there are several high data rate users in a WCDMA cell each requiring a OVSF channelisation code that has a small spreading factor. As previously stated, due to the nature in which OVSF codes are constructed, code resources are particularly limited on the downlink when a number of high data rate users are admitted to a cell. However, if these users are spatially separated, it is not unreasonable for them to share code resources (both channelisation and scrambling codes) in conjunction with adaptive beamforming, and thus increase the spectral efficiency/user capacity of the cell. This technique is more commonly known as space division multiple access (SDMA).

For a WCDMA system that exploits the spatial separation between users in a cell when assigning code resources (both channelisation and scrambling codes), it is necessary to consider the scenario in which two users (say) that share the code same resources move relative to each other so that their angular separation is no longer resolvable by the antenna arrangement. In such cases, codes need to be re-assigned otherwise the interference level at each user's mobile station becomes unacceptable.

Accordingly, the present invention comprises, in a first aspect, a method of code-assignment in a telecommunications system comprising a base station for providing communications services within a cell associated therewith and adapted to assign a

first set of channelisation codes C1(n) and a second set of channelisation codes C2(n), each code having a spreading factor associated therewith, the first set of channelisation codes having a first scrambling code associated therewith and the second set of channelisation codes having a second scrambling code associated therewith,

a plurality of mobile stations located within the cell, and an antenna arrangement associated with the base station for forming a plurality of angularly separated beams for enabling communication between the base station and the plurality of mobile stations,

the method including the steps of;

assigning a channelisation code C1(1) from the first set of channelisation codes to two mobile stations located in different antenna beams,

monitoring a parameter related to an angular separation of the two mobile stations, and when the parameter reaches a pre-set minimum value,

determining a number, N, of channelisation codes already assigned in the cell which have a spreading factor below a pre-set threshold, and if N is determined to be below a pre-chosen value,

re-assigning a different channelisation code C1(2) from the first set of channelisation codes to one of the two mobile stations,

otherwise, either,

re-assigning the same channelisation code C2(1) from the second set of channelisation codes to one of the two mobile stations, or

re-assigning a different channelisation code C2(2) from the second set of channelisation codes to one of said two mobile stations.

In a second aspect, the present invention comprises base station apparatus for providing communications services within a cell associated therewith and incorporating an antenna arrangement for forming a plurality of angularly separated beams for enabling communication between the base station and a plurality of mobile stations located within the cell,

and including a store for holding a first set of channelisation codes C1(n) and second set of channelisation codes C2(n), each code having a spreading factor associated therewith, the first set of channelisation codes having a first scrambling code associated therewith and the second set of channelisation codes having a second scrambling code associated therewith,

means for assigning a channelisation code C(1) from the first set of channelisation codes to two mobile stations located in different antenna beams,

means for detecting when an angular separation of the two mobile stations reaches a pre-set minimum value,

means for determining a number, N, of channelisation codes already assigned in the cell which have a spreading factor below a pre-set threshold,

means for re-assigning a different channelisation code C1(2) from the first set of channelisation codes to one of the two mobile stations when N is determined to be below a pre-chosen value,

and means for either,

re-assigning the same channelisation code C2(1) from the second set of codes to one of the two mobile stations,

or

re-assigning a different channelisation code C2(2) from the second set of channelisation codes to one of said two mobile stations,

when N is determined to be equal to or greater than the pre-chosen value.

The parameter related to angular separation of the two mobile stations may be the actual angular separation measured by the antenna arrangement. Alternatively, it may be relative signal strength measurements or relative signal quality measurements of signals received by the antenna arrangement from each of the two mobile stations or received by each of the two mobile stations from the antenna arrangement and reported back to the base station.

In one embodiment, the decisions regarding when and how to re-assign codes may be influenced by measurements, made by the base station, relating to the mobility of mobile stations within the cell and/or the spatial distribution of the mobile stations.

Preferably, initial assignment of the same channelisation code is made to mobile stations having an angular separation greater that a pre-set threshold.

Preferably, the time interval between code re-assignments is kept to the maximum possible in order to minimise the necessary signalling overhead (i.e. sending notification of the new code to the mobile stations).

The store may hold more than two sets of channelisation codes each having a different scrambling code associated with it.

Some embodiments of the invention will now be described, by way of example only, with reference to the drawings of which; Figure 1 is a schematic diagram of a cell comprising a telecommunications system and including base station apparatus operating in accordance with the invention and Figure 2 is a schematic block diagram of base station apparatus in accordance with the invention.

In Figure 1, a base station 1 provides communications services within an associated cell 2 to a plurality of mobile stations 3, 4, 5. The base station 1 incorporates an antenna array 6 which forms a plurality of beams 7,8, 9 which collectively cover the cell 2.

With reference now to Figure 2, the base station 2, includes a transceiver 10 connected to the antenna array 6 and to a measurement module 11. A first code store 12 holds a first set of channelisation codes C1(n) and a first scrambling code S1, and a second code store 13 holds a second set of channelisation codes C2(n) and second scrambling code S2. An output from each store 12, 13 is connected to an input of a code assignment module 14. A second input of the code assignment module 14 is connected to an output of the measurement module 11. An output of the code assignment module 14 is connected to the transceiver 10.

In operation and in accordance with a first example, the base station 2 is configured to provide communications services to the mobile stations 3, 4 and 5. One of the mobile stations 5 is a high data rate user and therefore has been assigned a channelisation code having a low spreading factor. The remaining mobile stations are low data rate users and so have been assigned channelisation codes with high spreading factors.

With reference to Figure 1, the mobile stations 3 and 4 have a large angular separation and are currently located in different antenna beams 7 and 8. Therefore, they can be assigned the same channelisation code, say C1(1), S1 from code store 12 and still be distinguished from one another by the base station 1.

Suppose that, subsequently, the mobile station 3 commences to move from its initial location (marked A in Figure 1) to a new location (marked B) which is just inside the beam 8 i.e. it moves closer to the mobile station 4 to a point where co-channel interference will be unacceptable.

The base station monitors the angular separation between the mobile stations 3 and 4 by, in the measurement module 11, monitoring the reported signal quality measurements from each of the two mobile stations 3 and 4. As the mobile station 3 approaches mobile station 4, the co-channel interference will increase and therefore signal quality will deteriorate. When one or both reported signal quality measurements from the two mobile stations 3, 4 reaches a pre-set level, then a code re-assignment needs to be effected.

In this case, the code assignment module 14 determines how many low spreading factor codes have already been assigned (i.e. if there is a large number or a small number of high data rate users in the cell). The code assignment module 14 compares the number, N, of assigned codes having a spreading factor value lower than some pre-chosen value with a pre-determined threshold. When N is lower than the threshold as in this example, because there is a small number of a high data rate users, then the code assignment module selects available channelisation code C1(2) from the code store 12 and re-assigns it to the mobile station 3 (via the transceiver 10 and antenna array 6).

This measure eliminates the increase in interference brought about by one mobile station's movement towards the other.

Changing the channelisation code rather than the scrambling code is done because the isolation between scrambling codes is, inherently, not as good as that between the channelisation codes (the cross-correlation product is not exactly zero for the scrambling codes, whereas the channelisation codes are all orthogonal).

In a second example, all the mobile stations 3, 4, 5 in the cell 2 are high data rate users and therefore a high number of low spreading factor codes have already been assigned.

Once again, assume that mobile station 3 moves from point A to point B and that the mobile stations 3 and 4 have initially been assigned the same channelisation code C1(1) from the same set of codes held in store 12.

Movement of the mobile station 3 is monitored by the antenna array 6 and when the angular separation between mobile stations 3 and 4 reaches a pre-set minimum

threshold, the measurement module 11 prompts the code assignment module 14 to effect a code re-assignment.

The code assignment module 14 determines that, this time, N is equal to or greater than the threshold and so assigns a low spreading factor code from the second set of codes in code store 13 to the mobile station 3.

## CLAIMS

1. A method of code assignment in a telecommunications system comprising a base station for providing communications services within a cell associated therewith and adapted to assign a first set of channelisation codes C1(n) and a second set of channelisation codes C2(n), each code having a spreading factor associated therewith, the first set of channelisation codes having a first scrambling code associated therewith and the second set of channelisation codes having a second scrambling code associated therewith,
a plurality of mobile stations located within the cell,
and an antenna arrangement associated with the base station for forming a plurality of angularly separated beams for enabling communication between the base station and the plurality of mobile stations,
the method including the steps of;
assigning a channelisation code C1(1) from the first set of channelisation codes to two mobile stations located in different antenna beams,
monitoring a parameter related to an angular separation of the two mobile stations,
and when the parameter reaches a pre-set minimum value,
determining a number, N, of channelisation codes already assigned in the cell which have a spreading factor below a pre-set threshold, and if N is determined to be below a pre-chosen value,
re-assigning a different channelisation code C1(2) from the first set of channelisation codes to one of the two mobile stations,
otherwise, either,
re-assigning the same channelisation code C2(1) from the second set of channelisation codes to one of the two mobile stations,
or
re-assigning a different channelisation code C2(2) from the second set of channelisation codes to one of said two mobile stations.

2. A method according to Claim 1 in which the parameter related to angular separation is the actual angular separation of the two mobile stations.

3. A method according to Claim 1 in which the parameter related to angular separation is strength of signals received from the base station at the two mobile stations.

4. A method according to Claim 1 in which the parameter related to angular separation is the strength of signals received at the base station from the two mobile stations.

5. A method according to Claim 1 in which the parameter related to angular separation is the quality of signals received from the base station at the two mobile stations.

6. A method according to Claim 1 in which the parameter related to angular separation is the quality of signals received at the base station from the two mobile stations.

7. Base station apparatus for providing communications services within a cell associated therewith and incorporating an antenna arrangement for forming a plurality of angularly separated beams for enabling communication between the base station and a plurality of mobile stations located within the cell, and including a store for holding a first set of channelisation codes C1(N) and a second set of channelisation codes C2(N), each code having a spreading factor associated therewith, the first set of channelisation codes having a first scrambling code associated therewith and the second set of channelisation codes having a second scrambling code associated therewith,
means for assigning a channelisation code C1(1) from the first set of channelisation codes to two mobile stations located in different antenna beams,
means for detecting when an angular separation of the two mobile stations reaches a pre-set minimum value,
means for determining a number, N, of channelisation codes already assigned in the cell which have a spreading factor below pre-set threshold,
means for re-assigning a different channelisation code C1(2) from the first set of channelisation codes to one of the two mobile stations when N is determined to be below a pre-chosen value,
and means for either,
re-assigning the same channelisation code C2(1) from the second set of codes to one of the two mobile stations,
or

re-assigning a different channelisation code C2(2) from the second set of channelisation codes to one of said two mobile stations when N is determined to be equal to or greater than the pre-chosen value.

8. A method of code assignment in a telecommunications system substantially as hereinbefore described with reference to the drawings.

CHARTER MARK

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INVESTOR IN PEOPLE

**Application No:** GB 0120188.8 12

**Claims searched:** All

**Examiner:** Dr Jan Miasik

**Date of search:** 18 March 2002

# Patents Act 1977
# Search Report under Section 17

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): H4L(LPRCA, LRRMN, LRRMR), H4P(PDCSL)

Int Cl (Ed.7): H04B1/69, H04B7/(06, 10, 216), H04Q7/(36, 38)

Other: Online: EPODOC, WPI, JAPIO

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage | | Relevant to claims |
|---|---|---|---|
| X,P | EP 1152628 A1 | (Matsushita Electric Industrial Co. Ltd.): see whole document, particularly para. 0064-0072 | 1, 2, 7 |
| Y | EP 1035677 A1 | (Lucent Technologies Inc.): see whole document | Y:1 |
| A | EP 1026911 A2 | (Lucent Technologies Inc.): see whole document | |
| A | WO 00/49816 A2 | (Nokia Networks OY): see whole document | |
| X,Y | WO 99/60809 A1 | (Telefonaktiebolaget LM Ericsson): see whole document, particularly fig. 6 | 1-3, 7<br>Y:1 |

**ORIGINAL**
**NO MARGINALIA**

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|---|---|---|---|
| X | Document indicating lack of novelty or inventive step | A | Document indicating technological background and/or state of the art. |
| Y | Document indicating lack of inventive step if combined with one or more other documents of same category. | P | Document published on or after the declared priority date but before the filing date of this invention. |
| & | Member of the same patent family | E | Patent document published on or after, but with priority date earlier than, the filing date of this application. |



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